

Treatment of Contaminants of Emerging Concern in Landfill Leachate

A report submitted pursuant to Act 21 of 2019

Submitted to: House Committees on Natural Resources, Fish and Wildlife and on Commerce and Economic Development and the Senate Committees on Natural Resources and Energy and on Economic Development, Housing and General Affairs

Submitted by: Agency of Natural Resources, Department of Environmental Conservation

February 5, 2020

Act 21 of 2019, Section 11: Agency of Natural Resources Contaminants of Emerging Concern Pilot Project

On or before January 15, 2020, the Agency of Natural Resources shall submit to the House Committees on Natural Resources, Fish and Wildlife and on Commerce and Economic Development and the Senate Committees on Natural Resources and Energy and on Economic Development, Housing and General Affairs a report regarding the management at landfills of leachate containing contaminants of emerging concern (CECs). The report shall include:

- (1) The findings of the leachate treatment evaluation conducted at any landfills in Vermont;*
- (2) The Agency of Natural Resources' assessment of the results of landfill leachate evaluations; and*
- (3) The Agency of Natural Resources' recommendations for treatment of CECs in leachate from landfills, including whether the State should establish a pilot project to test methods for testing or managing CECs in landfill leachate.*

Executive Summary

As required by the 2018 Solid Waste Facility Certification, the New England Waste Services of Vermont (NEWSVT) landfill has completed an evaluation of landfill leachate treatment options that would reduce or eliminate the discharge of per- and polyfluorinated substances (PFAS) resulting from the management and treatment of leachate at wastewater treatment facilities. This report provides an overview of that scoping study and presents the findings of two additional PFAS evaluations that were completed in 2019 evaluating PFAS concentrations within landfilled wastes, landfill leachate, and influent and effluent of municipal wastewater treatment facilities (WWTFs). Some of the significant conclusions of these three reports are:

- PFAS were found within all landfilled waste materials that were sampled, and the most significant contributors of PFAS loading within landfilled materials are residential materials, such as textiles, furniture, and carpets, as opposed to industrial waste materials.
- PFAS were observed in all WWTF influents, including those that do not accept any permitted industrial discharges, such as landfill leachate, that reasonably would have elevated PFAS concentrations, indicating that both industrial and residential sources of PFAS contribute to loading at WWTFs.
- PFAS were detected within landfill leachate and Vermont WWTFs that accept high volumes of landfill leachate have elevated concentrations of PFAS in their effluent when compared to WWTFs that do not accept landfill leachate.
- Treatment options are available and continue to evolve for reducing or eliminating contaminants of emerging concern (CECs), including PFAS, from landfill leachate and WWTF effluent. The science and technologies available for managing the waste residuals and potential air emissions from these treatment options are still developing.

Recommendations:

The Department of Environmental Conservation (Department) has initiated a third-party review of the landfill leachate treatment options to further our understanding of treatment options, effectiveness, and feasibility. The Department will also continue to move forward with consideration of PFAS within the permitting decisions of the Wastewater Management Program which implements the regulatory programs responsible for permitting industrial and commercial discharges, such as leachate, to municipal wastewater collection systems and treatment facilities, and permitting the discharge of effluent from WWTFs. Through this established process, the Department will work to determine what additional data and information, including any pilot testing of treatment systems, is necessary. Additionally, NEWSVT leachate will continue to be monitored for PFAS concentrations as part of the semi-annual monitoring required by the facility's Solid Waste Facility Certification. The Department does not, at this time, recommend initiating a pilot landfill leachate treatment system independent of the permitting process.

Introduction

Contaminants of emerging concern (CECs) refers to a broad suite of chemicals, primarily anthropogenic in nature, including pharmaceuticals, personal care products, endocrine disruptors, and nano-particles that enter the environment every day as a result of our modern lifestyles. The continual introduction of new chemicals for industrial uses and in consumer products is outpacing the development of toxicity data, standards, and regulation at the federal level. There may be limited information on the environmental and human health risks associated with CECs and CECs are generally unregulated. Our understanding of CECs continues to grow, and some are known to cause environmental harm or impact human health; this and the paucity of comprehensive information drives their identification as CECs with the potential to cause concern.

Landfills serve as repository for residential, industrial, and commercial wastes. Landfill leachate is the liquids passing through and produced by this complex mixture of disposed wastes. Landfill leachate includes a blend of chemicals and byproducts of degradation, including CECs, and is reflective of the products used within the area that the waste is collected from. Modern landfills are designed with leachate collection systems, which capture this liquid and allow it to be managed according to state regulations.

In Vermont there are currently five landfills that were constructed with liner systems to collect leachate; this leachate is transported to wastewater treatment facilities for management. Four of these five landfills have been closed and capped with materials that minimize the production of leachate, and therefore produce significantly lower volumes. The one active lined landfill that remains in Vermont is in Coventry and operated by New England Waste Services of Vermont (NEWSVT). It has been in operation since 1992. In calendar year 2018, it accepted 407,981 tons, or 76%, of the waste produced by Vermont's residents, businesses, and institutions for disposal. In 2018 the NEWSVT landfill produced 11.3 million gallons of leachate from the active and closed portions of the facility. This leachate was transported to wastewater treatment facilities in Montpelier and Newport, Vermont and Plattsburgh, New York.

In Vermont, concern regarding per- and polyfluoroalkyl substances (PFAS), a federally identified CEC, has risen following its detection in 2016 in groundwater in Bennington and North Bennington. Since that time, the Agency of Natural Resources (ANR) through the Department of Environmental Conservation (Department or DEC) has undertaken a proactive, systematic, ongoing investigation to identify likely sources of PFAS contamination. Concurrently, knowledge on PFAS use, presence, and toxicology has been rapidly expanding. This work has included investigation of PFAS within landfill leachate and within influent and effluent at wastewater treatment facilities, which serve as the primary receivers of waste originating from industrial and domestic uses. Preliminary analysis in 2018 identified the five PFAS compounds regulated in Vermont at a concentration of 3,365 ppt in the NEWSVT landfill leachate. This preliminary sampling event indicated the need for additional evaluation of PFAS within landfill leachate and at WWTFs that accept leachate.

Findings of Leachate Treatment Evaluations

As part of the Solid Waste Facility certification for expansion of the NEWSVT landfill issued in October 2018, the Department required NEWSVT to evaluate two on-site and two off-site leachate treatment options, including discussion of the treatment options' effectiveness in removing PFAS. Over the course of 2019, NEWSVT contracted with Brown and Caldwell to complete this evaluation. This report was submitted to the Department on October 15, 2019, in conformance with the certification requirement and

is provided as Attachment A to this report. To the Department's knowledge, no other evaluations of leachate treatment options have been completed by other landfills in Vermont.

All of the onsite treatment options evaluated are capable of treating leachate to non-detect levels of PFAS. The report identified the preferred onsite treatment approach to be reverse osmosis, with additional polishing of the landfill leachate, with direct discharge to a surface water. This treatment option would also result in the production of a PFAS-concentrated liquid waste (also containing other concentrated contaminants) that would require management, either through stabilization or destruction of the PFAS. An onsite treatment option which would result in zero discharge of liquids was also evaluated but would require evaporation of the liquid with significant energy input and would additionally require stabilization of the concentrated waste.

Off-site treatment options presented in the report focused on upgrading a wastewater treatment facility (WWTF) to either treating all of the WWTF effluent for the removal of PFAS or reducing the PFAS loading within the leachate prior to it being introduced to the WWTF. While the off-site treatment options provide opportunity for public-private partnerships and the potential for removing PFAS from the whole of the wastewater stream, there are challenges. The largest of these challenges is the capacity of any single wastewater treatment facility to accept all the produced leachate. Any of the WWTFs currently accepting some amount of landfill leachate would require significant upgrades and expansions to their facilities in order to attain the necessary capacity to be able to treat the full volume of leachate produced by the NEWSVT landfill.

Other PFAS Evaluations in 2019

In conjunction with the assessment of treatment options completed by NEWSVT in 2019, two other recent evaluations of PFAS provide important context. These include an evaluation of PFAS concentrations in materials being disposed at the landfill, which was completed by NEWSVT as required by the Department, and an additional characterization of PFAS within landfill leachate, wastewater treatment facility influents, effluents, and residuals which the Department contracted for completion.

Methodologies for sampling and analyzing PFAS in different media types have developed rapidly in the past several years and the work presented by these three studies relied on the best current practices. There currently is no EPA approved analysis method for PFAS in any media other than drinking water. The media (solids, bulky wastes, textiles, sludges, complex liquids) analyzed as part of the studies completed are inherently difficult to analyze, but the general consistency of the results over repeat sampling events, and repeat analysis of the same materials, indicates that these current analysis techniques are generating reproducible data that can reasonably be relied upon to help inform future decisions.

PFAS Within Disposed Materials

On October 15, 2019, in conformance with the certification requirement, NEWSVT submitted a report on PFAS concentration within various waste types being disposed of at the landfill (copy of the report can be found [here](#)). This sampling effort was targeted at materials with a high probability of having elevated PFAS concentrations and was intended to help identify if there were any sources of PFAS within the waste materials that could be managed differently in order to reduce PFAS loading within the landfill leachate.

Over 100 samples were taken to evaluate PFAS within materials, including sampling of municipal wastewater treatment facility sludges, industrial and paper sludges, bulky wastes (e.g. mattresses, couches), textiles (e.g. clothing, tents, fabric), construction and demolition debris (e.g. carpets, insulation, siding, shingles), and commercial wastes (e.g. food packaging, surface coaters, plastic manufacturers). This work found the highest concentrations of PFAS in bulky wastes (furniture), textiles, and carpeting.

Based on the disposal tonnages recorded by the landfill and a waste composition study completed by the Department in 2018, it is possible to estimate the mass of PFAS that is disposed of within the landfill due to the materials evaluated by this study. Because of their high average concentrations and disposal volumes, textiles contribute the greatest mass of PFAS to the waste mass, significantly higher than that from municipal and industrial sludges.

It is important to note that this study did not evaluate the contribution of traditional residential wastes. In addition to the textiles, bulky wastes, and carpeting that primarily derive from household disposal, there are other household wastes that may contribute to PFAS loading such as food packaging, non-stick products, cleaning products, and paints that are not accounted for by this analysis. Therefore, the total grams per day of PFAS disposed of within the landfill is greater than the mass reported by Figure 1 below.

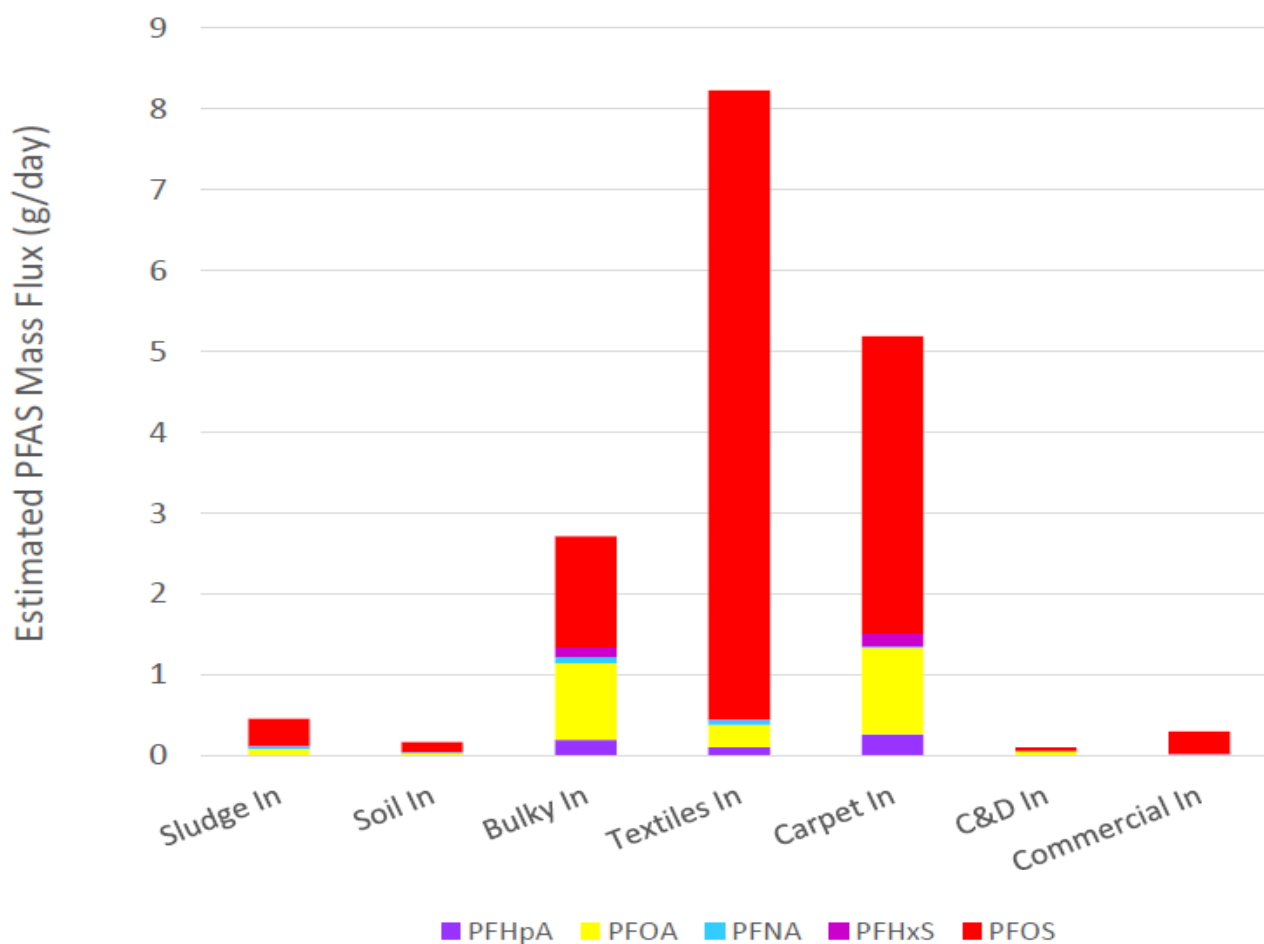


Figure 1: Regulated PFAS disposed of within the NEWSVT landfill from evaluated materials (modified from: PFAS Waste Source Testing Report, 2019)

PFAS Concentrations at Wastewater Treatment Facilities

In 2019, the Department contracted with Weston and Sampson for the completion of PFAS sampling and analysis of landfill leachate, WWTF influent, effluent, sludges, and biosolids. The goals for this work were to: 1) provide a better understanding of the variability of PFAS concentrations within these media, 2) inform our understanding of the contribution of landfill leachate to PFAS loading at a variety of WWTFs, and 3) evaluate the concentration of PFAS compounds in wastewater effluent and the end-products of treatment. A full copy of the report can be found [here](#).

Variability of PFAS concentrations. Preliminary sampling in 2018 (reported [here](#)) provided the basis for developing the 2019 sampling plan. This preliminary sampling was only a single sampling event, so one of the goals of this follow-up work was to better understand the degree of variability, both temporally and between different landfill and wastewater facilities. Given the potential for variation in wastes disposed of at a landfill and the wastewaters introduced to a WWTF, it seemed reasonable to presume that there would be corresponding variability in the concentrations of PFAS within leachate and effluent. Generally, the 2019 work, which consisted of multiple sampling events at each facility, indicates that concentrations are less variable than anticipated. Within the NEWSVT landfill leachate, the average concentration for the five regulated PFAS compounds was 3,088 ppt with a standard deviation of 486 ppt (Figure 2).

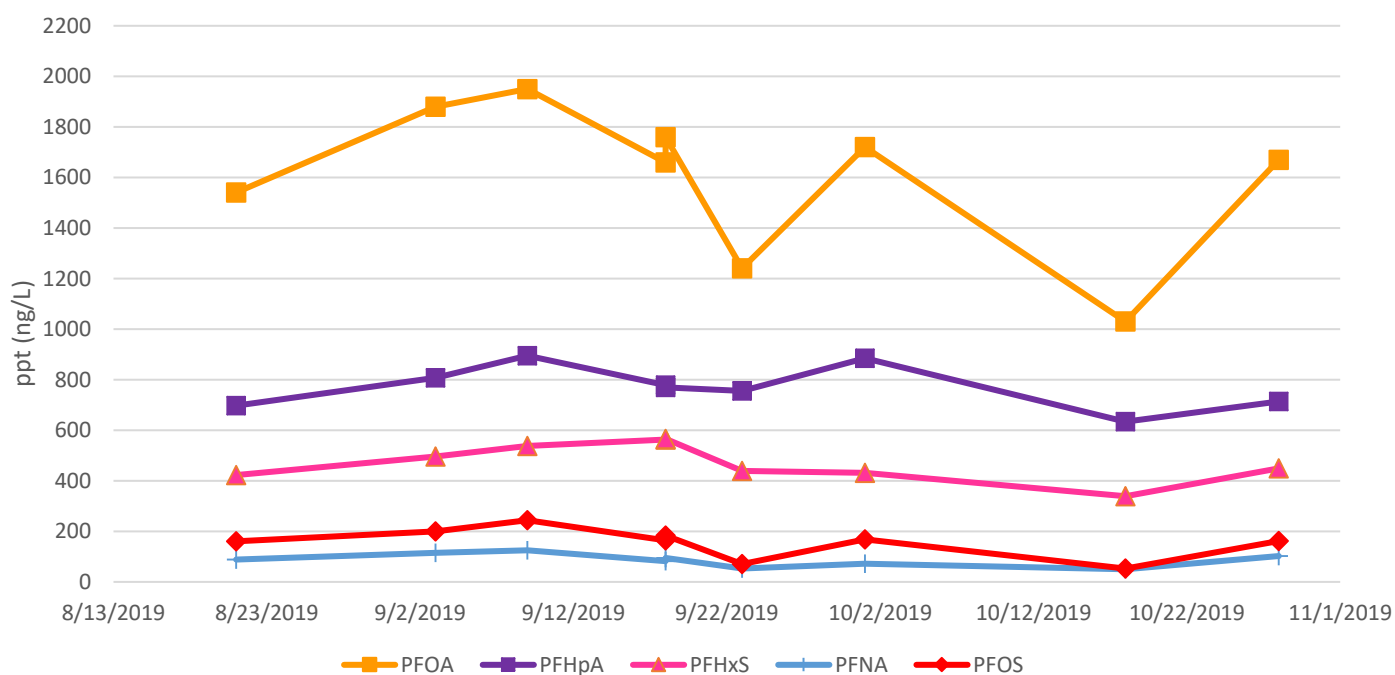


Figure 2: Results of repeat PFAS sampling of the NEWSVT landfill leachate.

Contribution of landfill leachate to PFAS loading at WWTFs. A larger sampling effort is currently underway that includes analyzing samples taken from WWTFs that accept leachate, WWTFs with other potentially elevated PFAS discharges and those that manage primarily domestic wastewater. Data available to date indicate that the WWTFs that accept high volumes of landfill leachate have significantly higher concentrations of PFAS in their effluent (Figure 3). However, all sampled WWTFs had detectable concentrations of PFAS in both the influent and effluent, confirming that leachate is not the sole contributing source of PFAS to wastewater.

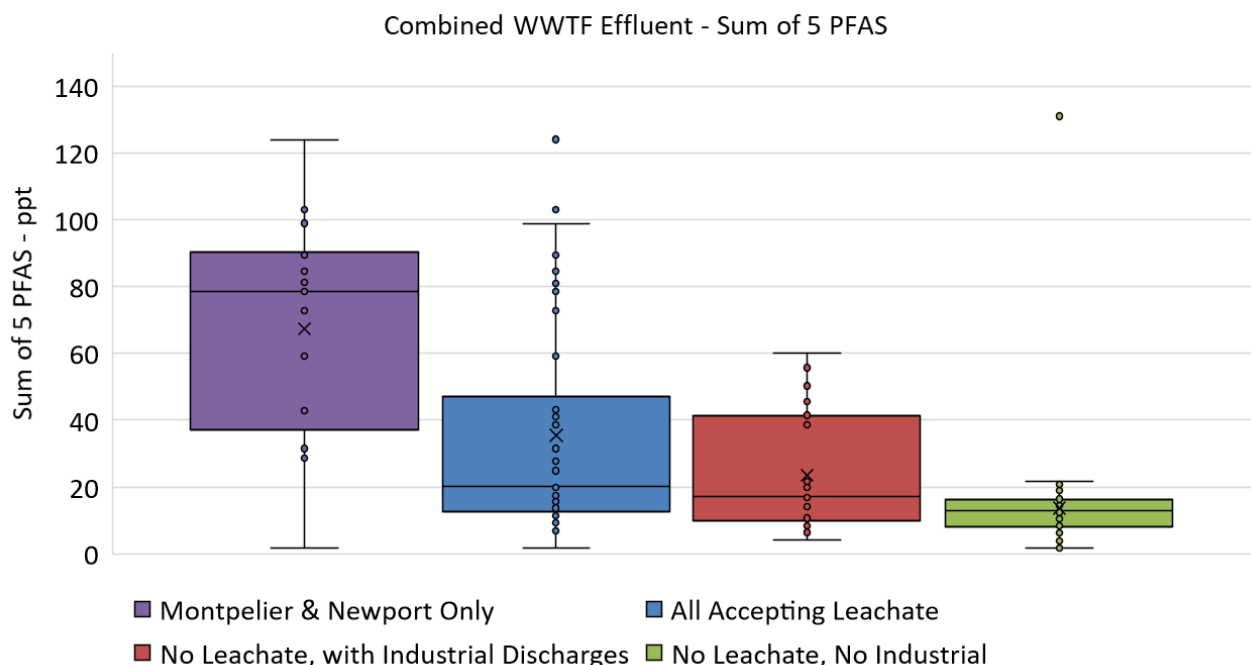


Figure 3: Concentrations of the five regulated PFAS compounds within sampled wastewater treatment facilities effluent.

PFAS in treated wastewater. CECs, including PFAS, are often difficult to remove with conventional wastewater treatment approaches. PFAS detected within the WWTF effluent samples represent what is being released to the environment at the discharge point of the facility. At facilities managing primarily domestic (residential) wastewaters, PFAS concentrations for the five Vermont regulated PFAS averaged below the drinking water health advisory of 20 ppt. At the Montpelier WWTF, which accepted the highest volume of leachate during the study period, effluent, at the discharge point, averaged 69 ppt for these same five PFAS compounds. Currently, Vermont has not established numeric surface water quality criteria for PFAS, and so there are no effluent limits for PFAS established in WWTF permits. Table 1 presents the mass of PFAS estimated to be discharged from select WWTFs that were sampled as part of this work. The Montpelier and Newport facilities, which managed the largest volumes of landfill leachate during this sample period, discharged the greatest mass of PFAS.

Table 1. Mass of PFAS discharged from selected wastewater treatment facilities during the sampling period of September-October 2019.

	Average Total Flow (Million gallons per day or MGD)	Average Leachate Volume Acceptance (gallons per day)	Effluent Concentration : Total PFAS (ppt)	Effluent Concentration : 5 Regulated PFAS (ppt)	Discharged mass of 5 Regulated PFAS (g/day)	Mass contributed by leachate* (g/day)
Montpelier	1.58	22,013	295	69	0.41	0.26
Newport	0.47	6,686	355	65	0.12	0.08
South Burlington – Bartlett Bay	0.66	---	108	13	.03	
Milton	0.23	---	113	19	.02	
Shelburne #1	0.22	---	79	12	.01	

*assumes a concentration of 3,088 ppt for the five regulated PFAS compounds, based on the average of NEWSVT leachate analyzed as part of the 2019 WWTF and landfill leachate sampling

Assessment of Leachate Treatment Options Evaluation and Recommendations

The analysis presented by Brown and Caldwell, on behalf of the NEWSVT landfill, included conceptual review of available and technically feasible leachate treatment options. As outlined in the Brown and Caldwell report, the ability to assess leachate treatment options is limited by the developing PFAS regulatory environment, the availability of proven treatment options, and the evolving scientific understanding of PFAS. Some of the unknowns include the degree to which PFAS will need to be removed and the absence of proven stabilization or destruction technologies that are capable of removing PFAS compounds to prevent releases to the environment. As a result, Brown and Caldwell was required to make significant assumptions within the report in order to address these unknowns that, in turn, have an impact on the feasibility and cost of the treatment options.

Currently, the combined cost of transporting and disposing of leachate from NEWSVT at the Montpelier WWTF is approximately 9 cents per gallon, while transport and disposal at the Plattsburg, NY WWTF costs 16 cents per gallon. Although other facilities are permitted to accept NEWSVT's leachate, it is likely that these two facilities will continue to accept the majority of the 11 million gallons (average last six years) of leachate produced annually by the landfill. Restrictions have been placed on the management of leachate within the Lake Memphremagog watershed through the issuance of a 2019 Act 250 Land Use Permit. As of October 2019, the Newport WWTF is no longer accepting NEWSVT leachate.

At an assumed ongoing average price of 12.5 cents a gallon, the traditional management of leachate costs on the order of \$1.4 million dollars a year. The Brown and Caldwell report does present an *Association for the Advancement of Cost Engineering* Class 5 estimate of the capital and operating costs associated with the four recommended treatment options. Class 5 estimates are based on conceptual engineering and only represent a planning level cost evaluation. For this reason, there is a broad range in the Class 5 costs presented which range from a low estimate of \$32 million to a high estimate of \$394.4 million for a total 20-year cost. It is important to note, however, that these cost estimates do not account for the treatment

components which are currently unknown (sequestration, solidification, or other off-site destruction) and therefore these estimates are limited.

In order to assure that the scoping study as submitted represents a reasonable assessment of landfill leachate treatment options and projected costs, the Department has issued an RFP for independent third-party review. This review will focus on assessing the report's completeness, representation of the feasibility of the treatment options, and projected costs. The completed review is anticipated by the end of April 2020.

This external assessment will be used to help inform the Department's evaluation of NEWSVT's management of leachate at WWTFs. Through this program, there is an established process for evaluating industrial and commercial discharges to municipal wastewater collection systems and treatment facilities, and for issuing permits as appropriate. This review includes assessment and regulation of discharges to municipal WWTFs in order to protect the WWTF, collection system, receiving water, and workers from adverse impacts caused by industrial discharges. This established process will help the Department determine what additional information, including any pilot testing of treatment systems, is necessary and can be required through the permitting process.

Additionally, the NEWSVT leachate will continue to be monitored for PFAS concentrations as part of the semi-annual monitoring required by the issued Solid Waste Facility Certification. Should there be any indication that there is a condition that poses a threat to human health or the environment, the Department will be able to require any necessary adjustments in operations or leachate management through the existing permits for the landfill or wastewater treatment facilities.

Conclusions

Both landfills and wastewater treatment facilities manage society's discarded waste, all of which has the potential to contain PFAS and other CECs. The removal of legacy CECs from the landfill leachate or treated wastewater effluent is complicated and evolving. Treatment to concentrate PFAS and limit the amount of these compounds discharged to the environment may be technically feasible, but typically results in a concentrated waste stream that requires further management. Assurance of the ultimate destruction or isolation of that concentrated waste stream remains unresolved. It is likely that the options and approaches to manage and treat landfill leachate and WWTF effluent will expand greatly in coming years as the science and our understanding continue to improve. Given the evolving nature of these issues, it will be essential to continually evaluate treatment options as well as identify and implement source control strategies that seek to reduce the use of PFAS in consumer products and industrial processes.